Autonomous and Mobile Robotics

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Humanoid Robots 1:

Introduction

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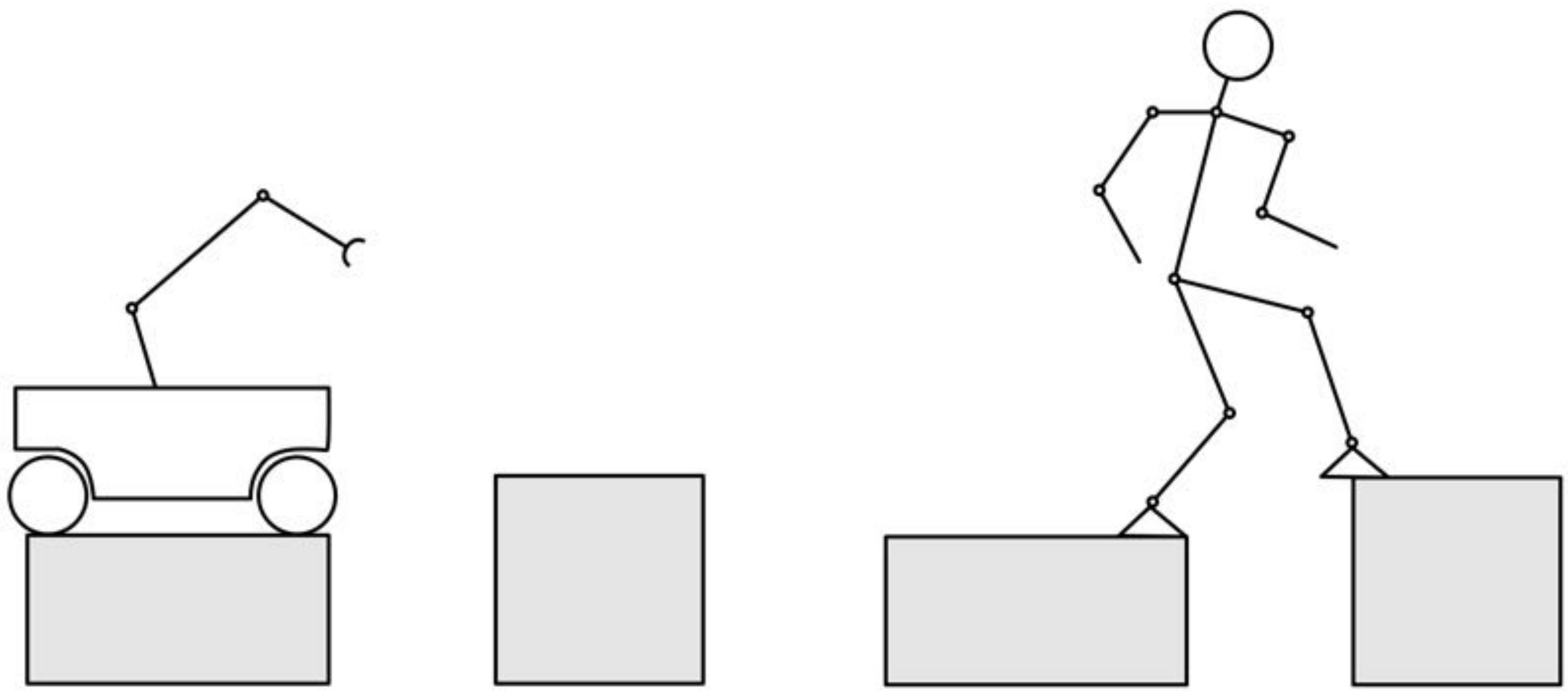
why humanoids

- practical reasons: in many cases humanoids are the most sensible choice



- psychological and commercial reasons: humanoids have a major appeal

why humanoids

- multipurpose: sensing, manipulation, locomotion etc…
- adaptability: humanoids can work in environments suitable for humans and expand their capabilities by using machines designed for humans
- collaboration: humanoid motion is easy for humans to understand and predict
- human-like appearance: empathy

some history

- pre-research period: humans always fascinated by the idea of building anthropomorphic machines
- pioneering period (1970s-1990s): initial research on biped prototypes
- new millennium: industrial companies showed that building actual humanoids was possible
- today: research focusing on humanoid robustness, efficiency and versatility

pre-research period

Hero's Automata
(1st century)

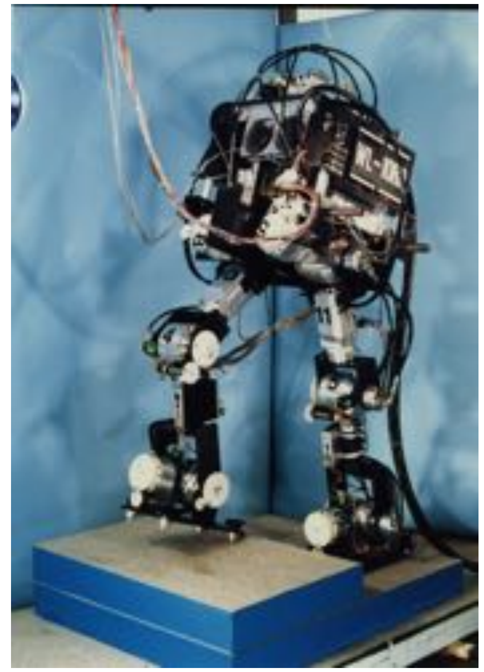
Karakuri Dolls
(17th–19th century)

Leonardo's Robot
(1495)

Asimov's Laws of Robotics
(1942)

pioneering period

WABOT-1
(Kato, 1973)



WL-10RD
(Kato, 1984)

P2
(Honda, 1996)

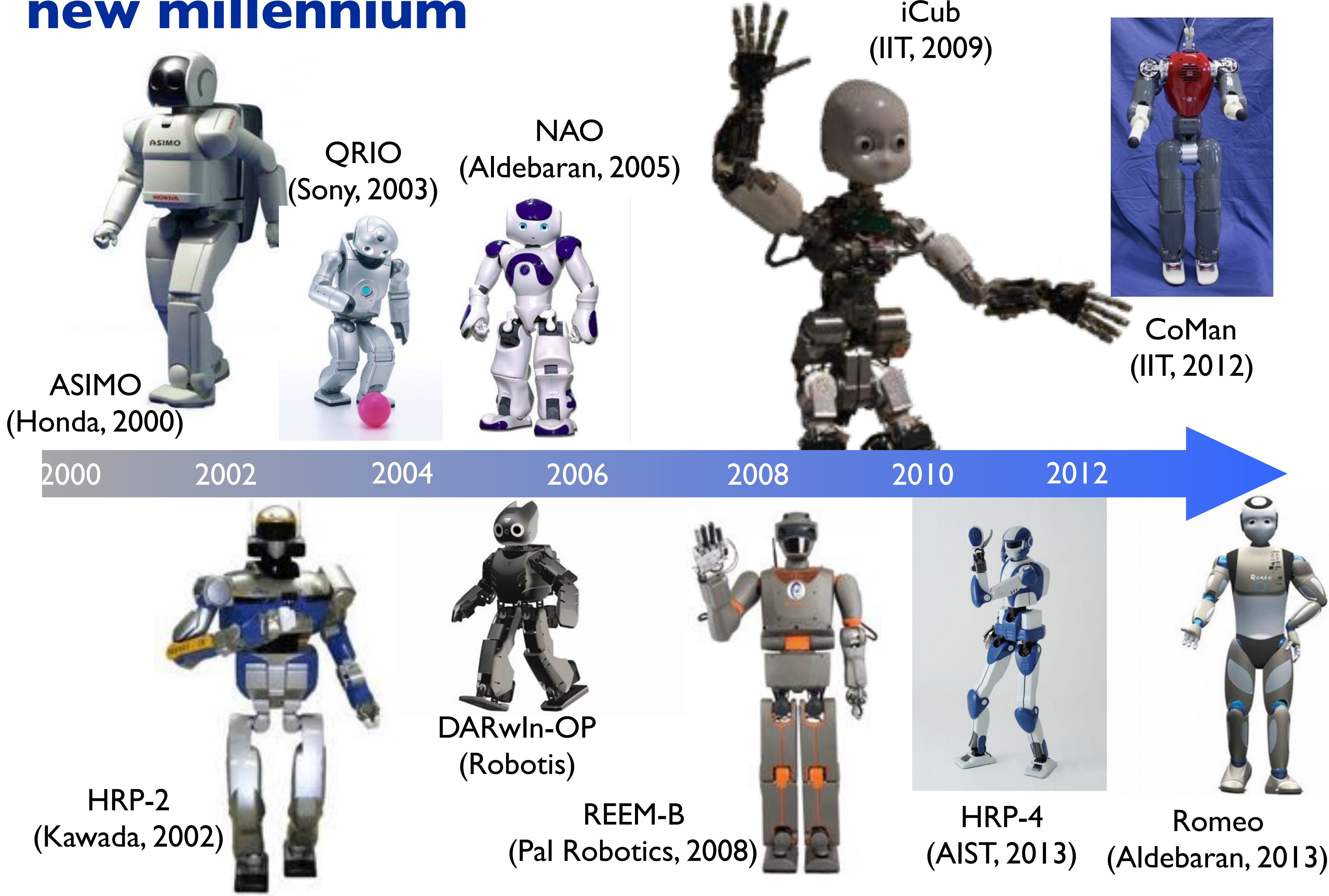
1970 1980 1990 2000

ZMP concept
(Vukobratović, 1972)

First computer-controlled robot
(Raibert, 70s-80s)

Purely passive dynamics
(McGeer, 1990)

new millennium



today

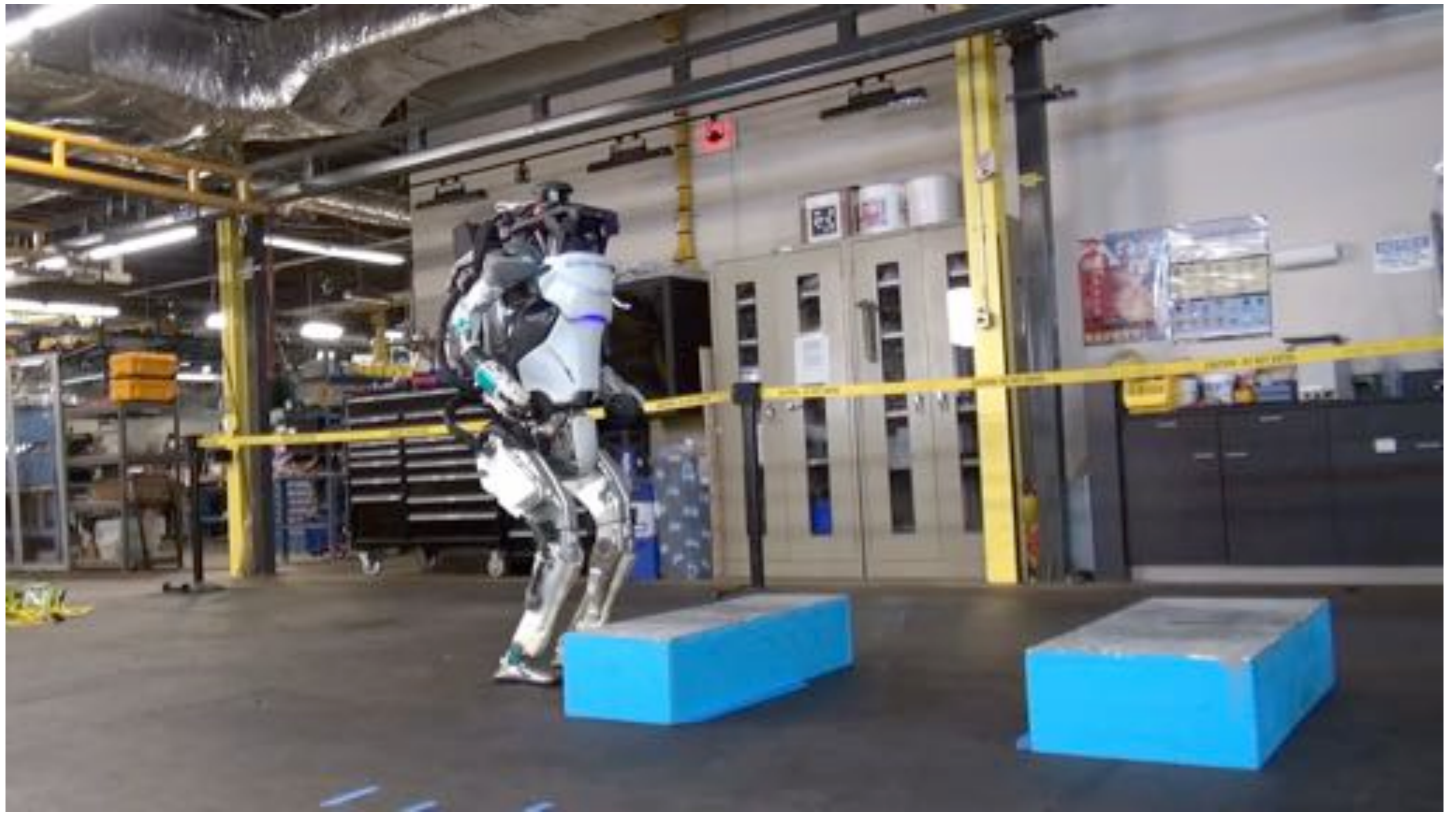
ATLAS
(Boston Dynamics)

TORO
(DLR)

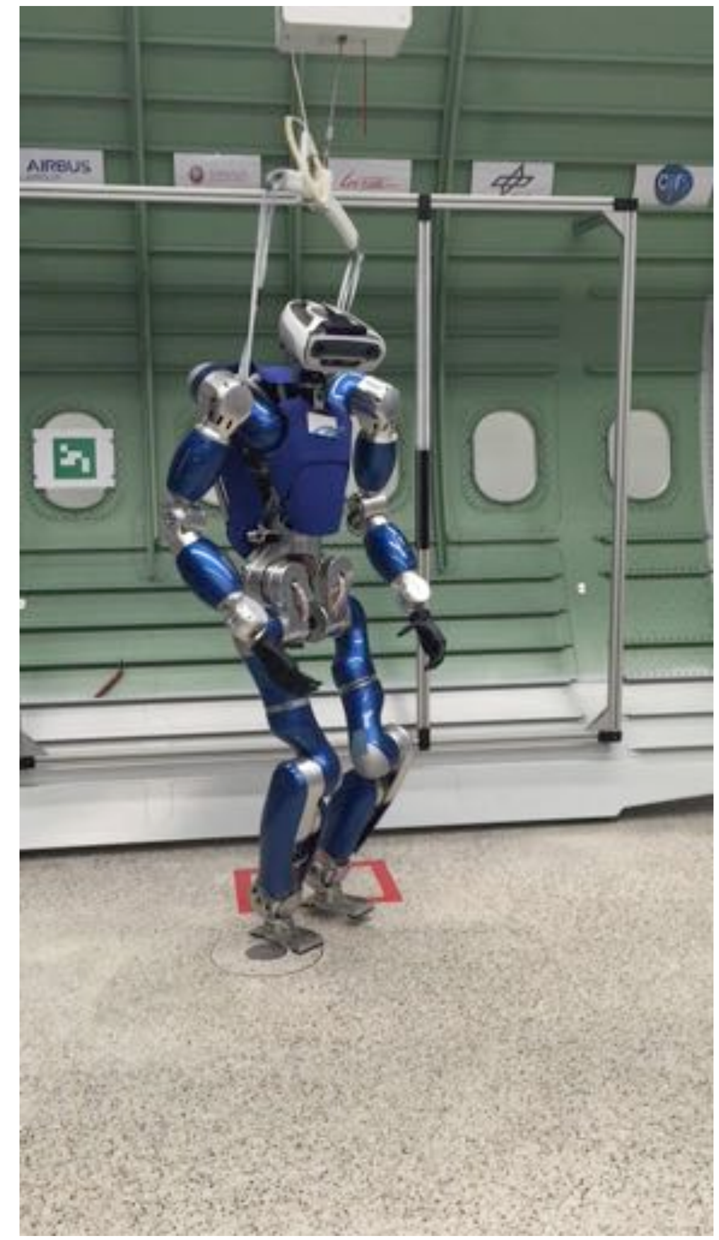
not only walking

running

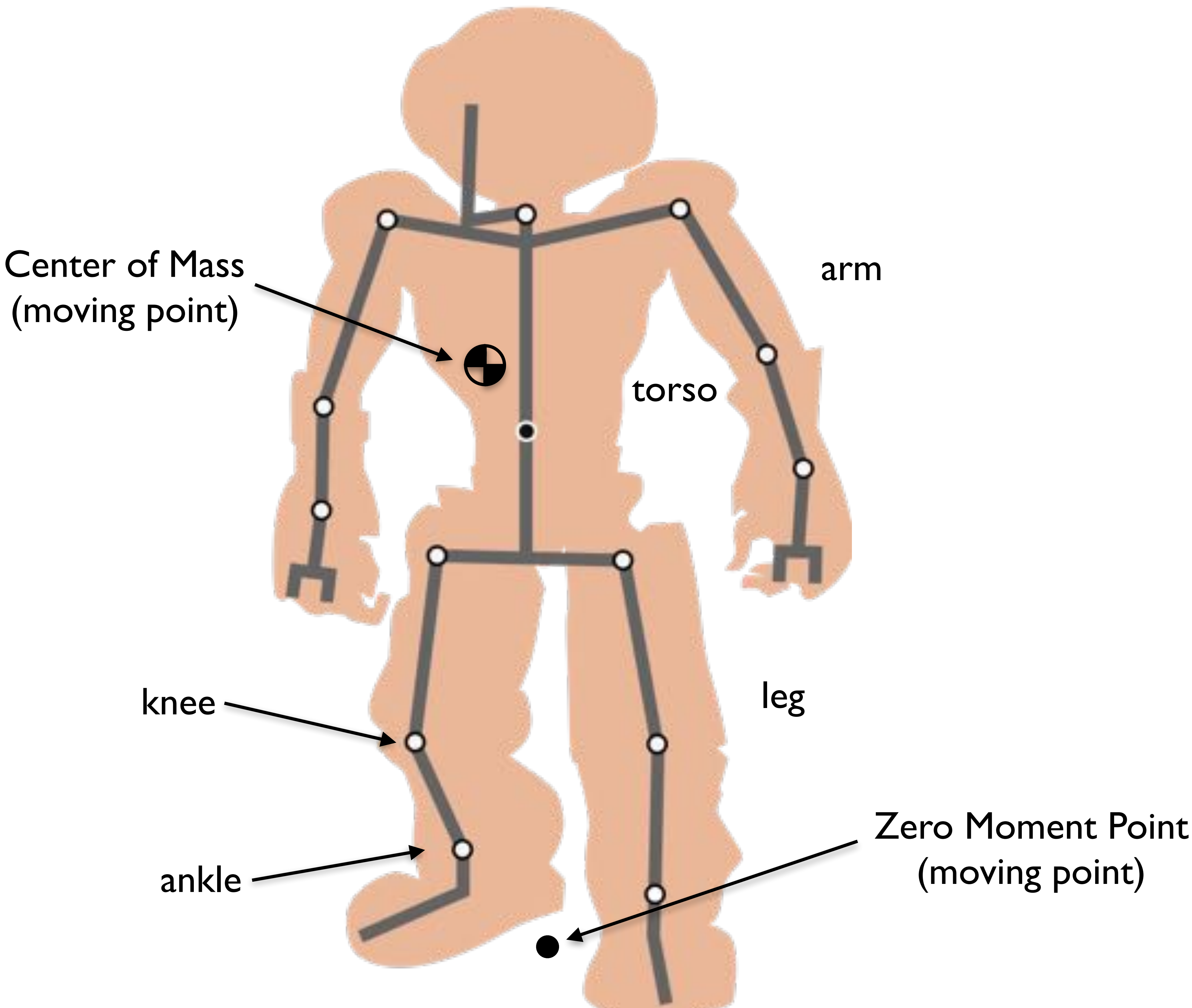
jumping



whole-body control

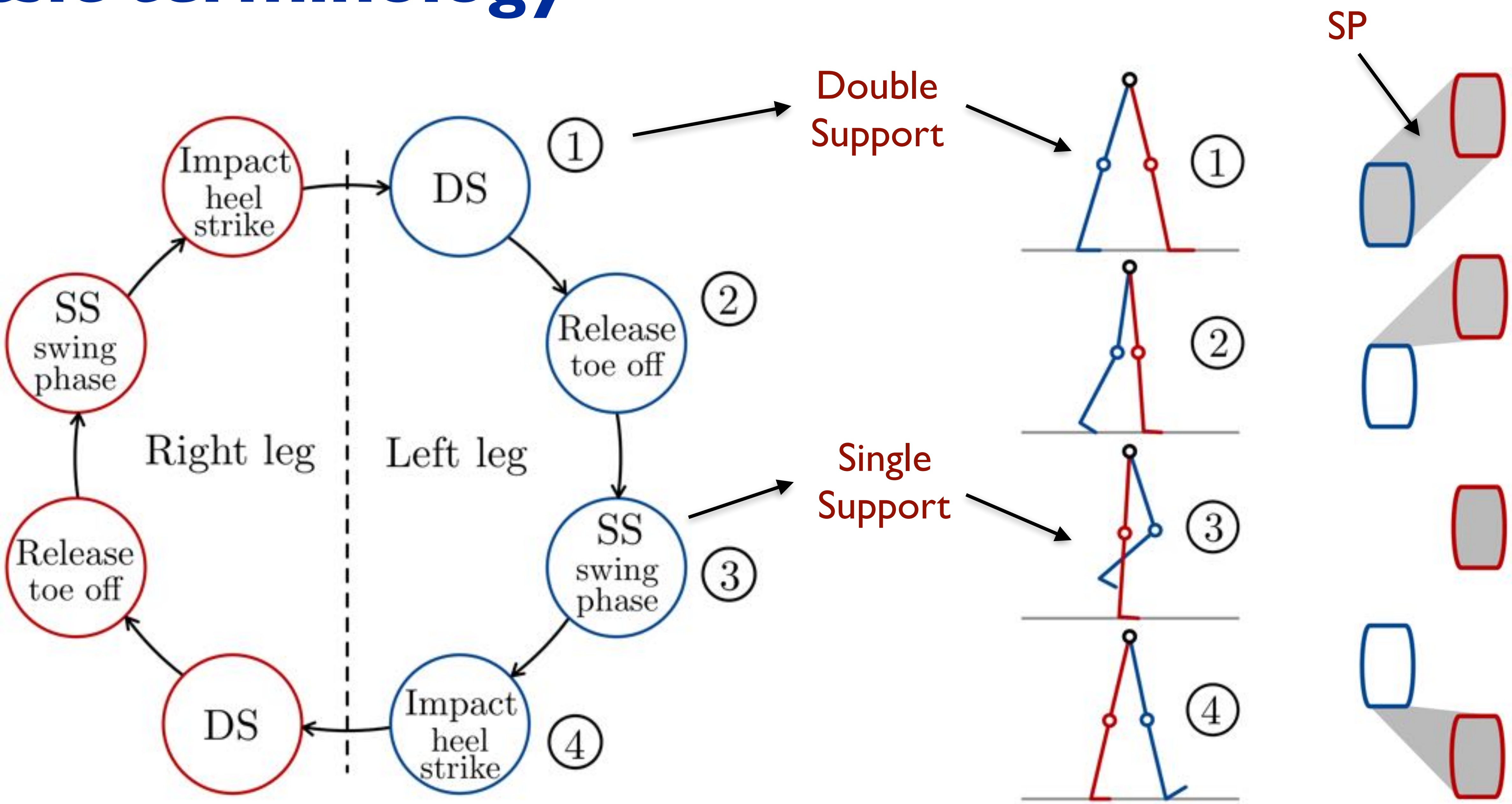


basic terminology



human walking: analysis

basic terminology

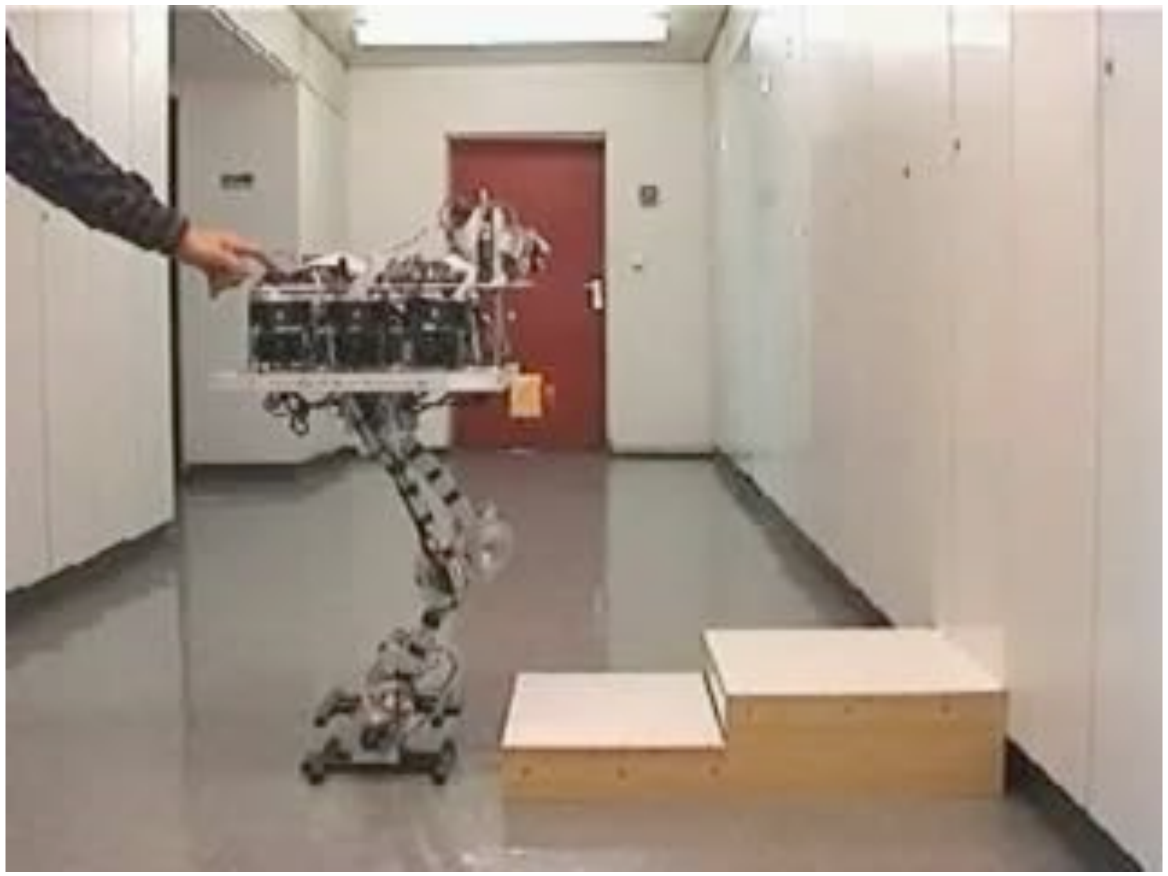


- walking: cyclic alternation of 4 phases
- Support Polygon (SP): convex hull of the contact points
- robots with flat feet have only Single and Double Support phases

gaits

- static(ally stable) gait: the projection of the CoM on the ground is always inside the SP
- however, static gaits are very slow and conservative
- Zero Moment Point (ZMP): point on the ground where the resultant of the reaction forces acts (more on this later)
- dynamic(ally stable) gait: the ZMP is always inside the SP

gaits



static walk

dynamic walk

passive (dynamic) walkers

- energy-efficient, natural gait (limit cycle)
- does not work on horizontal ground
- limited agility and responsiveness of motion

active (dynamic) walkers

- actuated joints (energy consumption)
- feedback control needed
- robots with flat feet or non-trivial feet